# Charles Darwin University

Final Examination

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|---|---|
| Family Name | |
| Given Name/s | |
| Student Number | |
| Teaching Period | Semester 1, 2018 |

| ENG221 – Analogue Electronics | DURATION | |
|---|---|---|
| | Reading Time: | 10 minutes |
| | Writing Time: | 180 minutes |

## INSTRUCTIONS TO CANDIDATES

- Exam has five questions.
- Answer all questions of the exam.
- Exam has 80 marks.

## EXAM CONDITIONS

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| <u>You may begin writing from the commencement of the examination session.</u> The reading time indicated above is provided as a guide only. |
| This is a CLOSED BOOK examination |
| Any non-programmable calculator is permitted |
| No handwritten notes are permitted |
| No dictionaries are permitted |

| ADDITIONAL AUTHORISED MATERIALS | EXAMINATION MATERIALS TO BE SUPPLIED |
|---|---|
| None | 1 x 20 Page Book<br>1 x Scrap Paper<br>Formula Sheet/s |

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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## Question 1 (10 marks)

For the amplifier shown in Figure 1, answer the following questions

a) Determine the DC voltage value of $V_{DS}$ (in volts). (3 marks)

b) Apply small-signal model of the transistor and determine the output resistance ($R_{out}$) of the amplifier. (7 marks)

Assume $I_D$=1mA ,$V_G$=2 V and $V_A$=20 V.

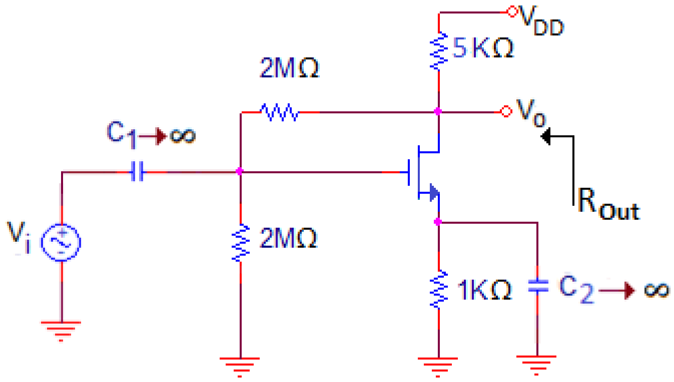


Figure 1.

## Question 2 (15 marks)

For the amplifier shown in Figure 2, answer the following questions.

a) Determine DC drain current of the circuit. (5 marks)
b) Determine the overall voltage gain of the amplifier ($v_o/v_s$). (10 marks)

Assume $k'_n(W/L)=2\ mA/V^2$ and $V_t=1V$.

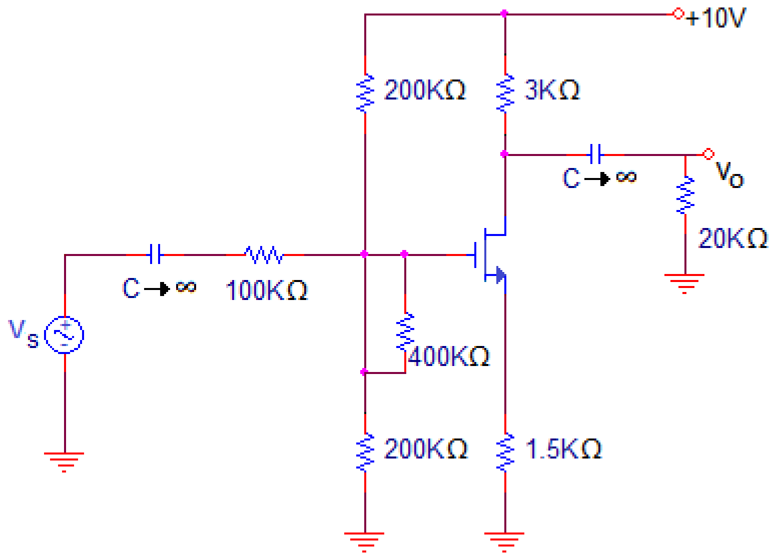


Figure 2.

**Question 3 (15 marks)**

For the circuit shown in Figure 3, determine a condition for the value of R so as it maintains the transistor in the active region.

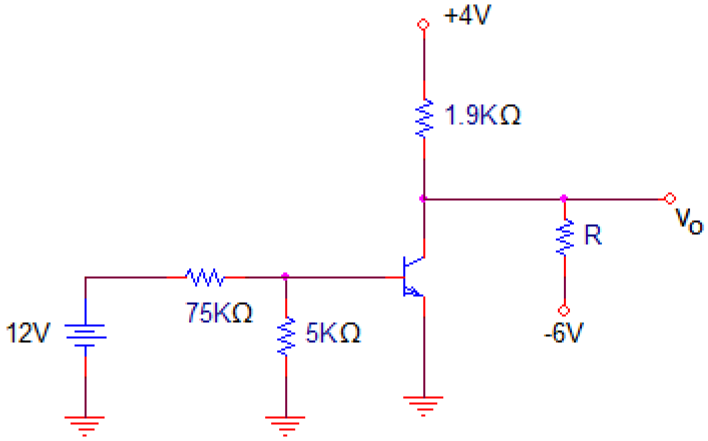


Figure 3.

Assume $V_{CE}$(saturation)=0.2 V and $\beta$=50.

## Question 4 (20 marks)

For the amplifier shown in Figure 4, answer the following questions.

a) Determine the DC Collector current of the circuit.(3 marks)
b) Determine the overall voltage gain of the amplifier ($v_o/v_s$). (10 marks)
c) Determine the input resistance of the amplifier ($R_{in}$). (5 marks)
d) Determine the output resistance of the amplifier ($R_{out}$).(2 marks)

Assume β=50. Ignore the Early effect.

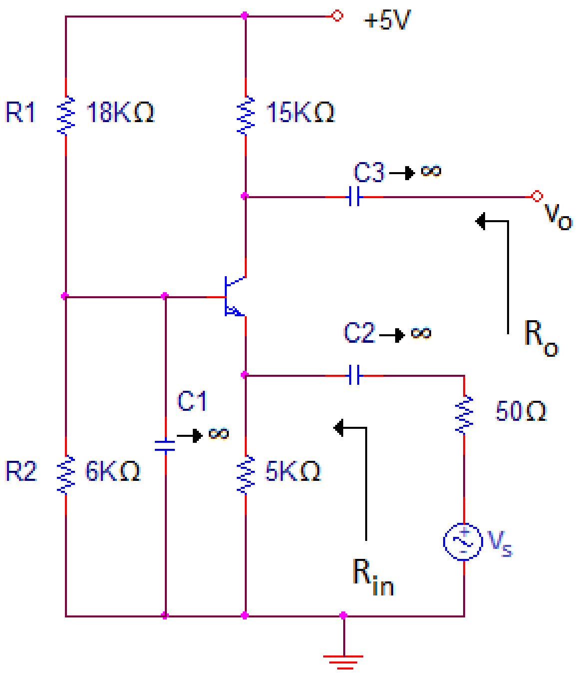


Figure 4.

## Question 5 (20 marks)

For the amplifier shown in Figure 5, answer the following questions.

a) Determine the DC emitter current value of the circuit. (6 marks)
b) Apply the small-signal model of the transistor (either $\pi$ or T model) and determine the overall voltage gain of the amplifier.(7 marks)
c) Apply the small-signal model of the transistor (either $\pi$ or T model) and determine the input resistance of the amplifier.(5 marks)
d) Consider the capacitance $C_2$ is open. Without using small-signal model of the transistor, determine the output resistance of the amplifier.(2 marks)

Assume $\beta$=50 and $V_A$=50 V.

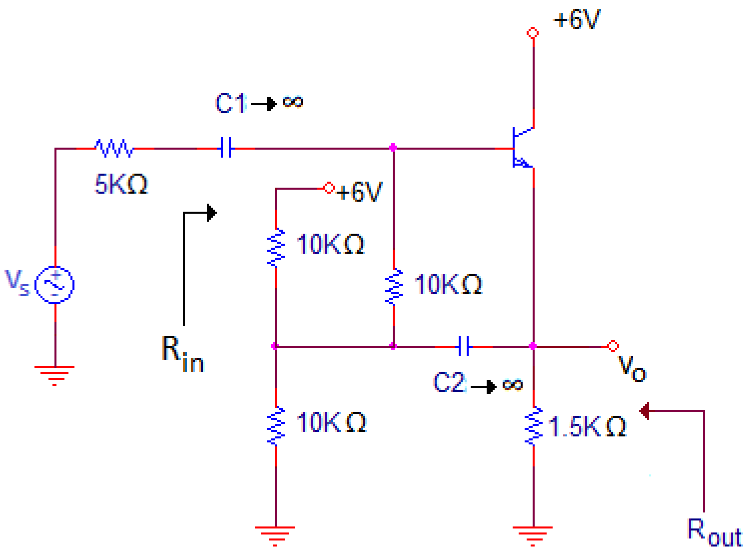


Figure 5.

**Formula sheet**

**NMOSET**

$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(v_{GS} - V_t)^2(1+\frac{v_{DS}}{V_A}) = \frac{1}{2}k_n'\frac{W}{L}(v_{GS} - V_t)^2(1+\frac{v_{DS}}{V_A})$$

$$g_m = (\mu_n C_{ox})\left(\frac{W}{L}\right)V_{OV} = \sqrt{2(\mu_n C_{ox})\left(\frac{W}{L}\right)I_D}$$

$$r_o = \frac{V_A}{I_D}$$

$$V_A = \frac{1}{\lambda} \qquad g_m = \frac{I}{V_{OV}/2}$$

**PMOSFET**

$$i_D = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}(v_{SG} - |V_t|)^2(1+\frac{v_{SD}}{V_A}) = \frac{1}{2}k_p'\frac{W}{L}(v_{SG} - |V_t|)^2(1+\frac{v_{SD}}{V_A})$$

$$g_m = (\mu_p C_{ox})\left(\frac{W}{L}\right)V_{OV} = \sqrt{2(\mu_p C_{ox})\left(\frac{W}{L}\right)I_D}$$

$$r_o = \frac{|V_A|}{I_D}$$

$$V_A = \frac{1}{\lambda}$$

**BJT**

$$i_C = I_S e^{v_{BE}/V_T}(1+\frac{v_{CE}}{V_A})$$

$$i_B = \frac{i_C}{\beta} \qquad \Delta I_B = \frac{\Delta I_C}{\beta}$$

$$g_m = \frac{I_C}{V_T}$$

$$g_m r_e = \alpha$$

$$\alpha = \frac{\beta}{\beta+1}$$

$$r_\pi = \frac{\beta}{g_m}$$

$$r_o = \frac{V_A}{I_C}$$

$V_T$=25 mV $\quad$ $V_{BE}$=0.7 V